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Heat-sealable filter material with biodegradable polymers

Heat-sealable filter material containing biodegradable polymers

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This invention relates to a filter material consisting of at least one ply of natural fibres and at least a second ply of heat-sealable synthetic material, which is biodegradable.

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EP-A 0 380 127 A2 describes, for example, a heat-sealable tea bag paper and the process for the production thereof, wherein the heat-sealing phase contains polyethylene and/or polypropylene and/or a copolymer of vinyl chloride and vinyl acetate and the basis weight of this material is between 10 and 15 g/m².

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EP-A 656 224 (application number 94 107 709.1) describes a filter material, in particular for the production of tea bags and coffee bags or filters, having a basis weight of between 8 and 40 g/m², in which the heat-sealing ply consists of plastic fibres, preferably polypropylene or polyethylene, which are laid in the heated state onto the first ply consisting of natural fibres.

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German application DE-A 2 147 321 (US priority 23.09.70, US 74 722) describes a thermoplastic, heat-sealable composition consisting of a polyolefin powder (polyethylene or polypropylene) which is embedded in a matrix material of vinyl chloride/vinyl acetate copolymer. This material is also used to provide a heat-sealable finish on a fibrous material produced using papermaking techniques.

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All these stated filter materials require a content of at least 20 to 30 wt.% of thermoplastic material, relative to the total basis weight of the filter material, in order to produce a filter bag by heat sealing.

It is known that used filter materials, for example tea bags, coffee bags or also other filters are disposed of on a compost heap or in the biowaste bin. After a certain period of time, which is dependent upon further parameters such as temperature, atmospheric humidity, microorganisms *etc.*, the natural fibre component of the filter bag has decomposed and biodegraded, while the thermoplastic network of polymer fibres remains and reduces the quality of the compost.

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On the other hand, it is not possible to separate the natural fibre component from the thermoplastic, non-biodegradable polymer, *i.e.* the used filter bag would have to be classed as non-reutilisable waste (grey bin).

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The object of the invention is accordingly to provide a completely biodegradable, heat-sealable filter material which is compostable, so constituting the most favourable solution both environmentally and economically. It is also intended to describe processes for the production of such filter materials.

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The present invention provides a filter material consisting of an at least two-ply structure, wherein at least one ply contains natural fibres and one ply biodegradable, thermoplastic fibres, wherein the thermoplastic fibres are selected from the group comprising aliphatic or partially aromatic polyesteramides, aliphatic or partially aromatic polyesters, aliphatic or partially aromatic polyesterurethanes, aliphatic or aliphatic-aromatic polyestercarbonates.

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Thermoplastic fibres may both be applied onto the ply of natural fibres in an operation on the papermaking machine and laid onto this paper ply of natural fibres in the heated state using a melt-blowing process and be fused both with themselves and with the paper ply.

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The first ply of the filter material generally has a basis weight of between 8 and 40 g/m², preferably of 10 to 20 g/m² and air permeability of 300 to 4000 l/m²·sec (DIN 53 887), preferably of 500 to 3000 l/m²·sec.

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The second layer of the filter material preferably has a basis weight of 1 to 15 g/m², preferably of 1.5 to 10 g/m².

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The first ply of the filter material made from natural fibres is preferably provided with wet strength.

The filter material is used, for example, for the production of tea bags, coffee bags or tea or coffee filters.

The filter material may be produced in the following manner:

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In a first stage, an aqueous suspension of the natural fibres is applied onto a paper-making machine wire and, in a second stage, the heat-sealable, biodegradable polymer fibres are laid onto the natural fibre layer in such a manner that they partially penetrate the natural fibre layer, wherein interpenetration of the two layers may be adjusted by the degree of dewatering on the wire. Known natural fibres, such as hemp, manilla, jute, sisal and others, as well as long-fibre woodpulp, are used for the first layer and produced on a papermaking machine in a manner known *per se*.

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According to the invention, a biodegradable, thermoplastic polymer in fibre form is used for the second layer, which polymer is selected from the group comprising aliphatic or partially aromatic polyesteramides, aliphatic or partially aromatic polyesters, aliphatic or partially aromatic polyesterurethanes, aliphatic or aliphatic-aromatic polyestercarbonates.

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Biodegradable and compostable polymers which may be considered are aliphatic or partially aromatic polyesters, thermoplastic aliphatic or partially aromatic polyesterurethanes, aliphatic or aliphatic-aromatic polyestercarbonates, aliphatic or partially aromatic polyesteramides.

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The following polymers are suitable:

aliphatic or partially aromatic polyesters prepared from

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A) aliphatic bifunctional alcohols, preferably linear C₂ to C₁₀ dialcohols, such as for example ethanediol, butanediol, hexanediol or particularly preferably butanediol and/or optionally cycloaliphatic bifunctional alcohols, preferably having 5 or 6 C atoms in the cycloaliphatic ring, such as for example cyclohexanedimethanol, and/or, partially or entirely instead of the diols, monomeric

or oligomeric polyols based on ethylene glycol, propylene glycol, tetrahydrofuran or copolymers thereof having molecular weights of up to 4000, preferably of up to 1000, and/or optionally small quantities of branched bifunctional alcohols, preferably C_3 - C_{12} alkyldiols, such as for example neopentyl glycol, and additionally optionally small quantities of more highly functional alcohols, such as for example 1,2,3-propanetriol or trimethylolpropane and from aliphatic bifunctional acids, preferably C_2 - C_{12} alkyldicarboxylic acids, such as for example and preferably succinic acid, adipic acid and/or optionally aromatic bifunctional acids, such as for example terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid and additionally optionally small quantities of more highly functional acids, such as for example trimellitic acid or

B) from acid- and alcohol-functionalised units, preferably having 2 to 12 C atoms in the alkyl chain, for example hydroxybutyric acid, hydroxyvaleric acid, lactic acid or the derivatives thereof, for example ϵ -caprolactone or dilactide,

or a mixture and/or a copolymer prepared from A and B,

wherein the aromatic acids constitute a fraction of no more than 50 wt.%, relative to all the acids.

Aliphatic or partially aromatic polyesterurethanes prepared from

C) aliphatic bifunctional alcohols, preferably linear C_2 to C_{10} dialcohols, such as for example ethanediol, butanediol, hexanediol, particularly preferably butanediol and/or optionally cycloaliphatic bifunctional alcohols, preferably having a C_5 or C_6 cycloaliphatic ring, such as for example cyclohexanedi-methanol, and/or, partially or entirely instead of the diols, monomeric or oligomeric polyols based on ethylene glycol, propylene glycol, tetrahydrofuran or copolymers thereof having molecular weights of up to 4000, preferably of up to 1000, and/or optionally small quantities of branched bifunctional alcohols, preferably C_3 - C_{12} alkyldiols, such as for example neopentyl glycol, and

5 additionally optionally small quantities of more highly functional alcohols, preferably C_3 - C_{12} alkylpolyols, such as for example 1,2,3-propanetriol or trimethylolpropane and from aliphatic bifunctional acids, preferably C_2 - C_{12} alkyldicarboxylic acids, such as for example and preferably, succinic acid, adipic acid, and/or optionally aromatic bifunctional acids, such as for example terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid and additionally optionally small quantities of more highly functional acids, such as for example trimellitic acid, or

10 D) from acid- and alcohol-functionalised units, for example having 2 to 12 C atoms, for example hydroxybutyric acid, hydroxyvaleric acid, lactic acid or the derivatives thereof, for example ϵ -caprolactone or dilactide,

or a mixture and/or a copolymer prepared from C and D,

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wherein the aromatic acids constitute a fraction of no more than 50 wt.%, relative to all the acids;

20 E) from the reaction product of C and/or D with aliphatic and/or cycloaliphatic bifunctional and additionally optionally more highly functional isocyanates, preferably having 1 to 12 C atoms or 5 to 8 C atoms in the case of cycloaliphatic isocyanates, for example tetramethylene diisocyanate, hexamethylene diisocyanate, isophorone diisocyanate, optionally additionally with linear and/or branched and/or cycloaliphatic bifunctional and/or more highly functional alcohols, preferably C_3 - C_{12} alkyl diols or alkylpolyols or 5 to 8 C atoms in the case of cycloaliphatic alcohols, for example ethanediol, hexanediol, butanediol, cyclohexanedimethanol, and/or optionally additionally with linear and/or branched and/or cycloaliphatic bifunctional and/or more highly functional amines and/or aminoalcohols preferably having 2 to 12 C atoms in the alkyl chain, for example ethylenediamine or aminoethanol, and/or optionally further modified amines or alcohols, such as for example ethylenediaminoethanesulphonic acid, as the free acid or as a salt,

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wherein the ester fraction C) and/or D) amounts to at least 75 wt.%, relative to the sum of C), D) and E).

5 Aliphatic or aliphatic-aromatic polyestercarbonates prepared from

10 F) aliphatic bifunctional alcohols, preferably linear C_2 to C_{10} dialcohols, such as for example ethanediol, butanediol, hexanediol or particularly preferably butanediol and/or optionally cycloaliphatic bifunctional alcohols, preferably having 5 to 8 C atoms in the cycloaliphatic ring, such as for example cyclohexanedimethanol, and/or, partially or entirely instead of the diols, monomeric or oligomeric polyols based on ethylene glycol, propylene glycol, tetrahydrofuran or copolymers thereof having molecular weights of up to 4000, preferably of up to 1000, and/or optionally small quantities of branched bifunctional alcohols, preferably with C_2 - C_{12} alkyldicarboxylic acids, such as for example neopentyl glycol, and additionally optionally small quantities of more highly functional alcohols, such as for example 1,2,3-propanetriol or trimethylolpropane and from aliphatic bifunctional acids, such as for example and preferably, succinic acid, adipic acid, and/or optionally aromatic bifunctional acids, such as for example terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid and additionally optionally small quantities of more highly functional acids, such as for example trimellitic acid, or

25 G) from acid- and alcohol-functionalised units, for example having 2 to 12 C atoms in the alkyl chain, for example hydroxybutyric acid, hydroxyvaleric acid, lactic acid or the derivatives thereof, for example ϵ -caprolactone or dilactide,

or a mixture and/or a copolymer prepared from F and G,

30 wherein the aromatic acids constitute a fraction of no more than 50 wt.%, relative to all the acids,

H) a carbonate fraction which is produced from aromatic bifunctional phenols, preferably bisphenol A, and carbonate donors, for example phosgene, or

5 a carbonate fraction which is produced from aliphatic carbonic acid esters or the derivatives thereof, such as for example chlorocarbonic acid esters or aliphatic carboxylic acids or the derivatives thereof, such as for example salts and carbonate donors, for example phosgene, wherein

10 the ester fraction F) and/or G) amounts to at least 70 wt.%, relative to the sum of F), G) and H).

Aliphatic or partially aromatic polyesteramides prepared from

15 I) aliphatic bifunctional alcohols, preferably linear C_2 to C_{10} dialcohols, such as for example ethanediol, butanediol, hexanediol, particularly preferably butanediol and/or optionally cycloaliphatic bifunctional alcohols, preferably having 5 to 8 C atoms, such as for example cyclohexanedimethanol, and/or, partially or entirely instead of the diols, monomeric or oligomeric polyols based on ethylene glycol, propylene glycol, tetrahydrofuran or copolymers thereof having molecular weights of up to 4000, preferably of up to 1000, and/or optionally small quantities of branched bifunctional alcohols, preferably C_3 - C_{12} alkyl diols, such as for example neopentyl glycol, and additionally optionally small quantities of more highly functional alcohols, preferably C_3 - C_{12} alkyl polyols, such as for example 1,2,3-propanetriol, trimethylolpropane and from aliphatic bifunctional acids, preferably having 2 to 12 C atoms in the alkyl chain, such as for example and preferably succinic acid, adipic acid and/or optionally aromatic bifunctional acids, such as for example terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid and additionally optionally small quantities of more highly functional acids, such as for example trimellitic acid or

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K) from acid- and alcohol-functionalised units, preferably having 2 to 12 C atoms in the carbon chain, for example hydroxybutyric acid, hydroxyvaleric acid, lactic acid or the derivatives thereof, for example ϵ -caprolactone or dilactide,

5 or a mixture and/or a copolymer prepared from I) and K),

wherein the aromatic acids constitute a fraction of no more than 50 wt.%, relative to all the acids,

10 L) an amide fraction prepared from aliphatic and/or cycloaliphatic bifunctional and/or optionally small quantities of branched bifunctional amines, with linear aliphatic C₂ to C₁₀ diamines being preferred, and additionally optionally small quantities of more highly functional amines, the amines preferably being hexamethylenediamine, isophoronediamine and particularly preferably hex-

15 amethylenediamine, and from linear and/or cycloaliphatic bifunctional acids, preferably having 2 to 12 C atoms in the alkyl chain or a C₅ or C₆ ring in the case of cycloaliphatic acids, preferably adipic acid, and/or optionally small quantities of branched bifunctional and/or optionally aromatic bifunctional acids, such as for example terephthalic acid, isophthalic acid, naphthalene-

20 dicarboxylic acid and additionally optionally small quantities of more highly functional acids, preferably having 2 to 10 C atoms, or

M) from an amide fraction prepared from acid- and amine-functionalised units, preferably having 4 to 20 C atoms in the cycloaliphatic chain, preferably

25 ω -lauro lactam, ϵ -caprolactam, particularly preferably ϵ -caprolactam,

or a mixture prepared from L) and M) as the amide fraction, wherein

the ester fraction I) and/or K) amounts to at least 30 wt.%, relative to the sum of I),

30 K), L) and M), with the fraction by weight of the ester structures preferably amounting to 30 to 70 wt.%, and the fraction of the amide structures to 70 to 30 wt.%.

During the production process, the synthetic biodegradable heat-sealing fibres of the second ply partially penetrate the first ply and, during the drying process on the papermaking machine, in a molten state enclose the natural fibres. The pores necessary for filtration are kept clear during this operation.

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The invention is illustrated below by means of the drawings.

Figure 1 shows a general, broadly diagrammatic representation of the various stages in the formation of the filter material according to the invention from natural fibres and synthetic fibres.

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Figure 1 shows a diagrammatic representation of the formation of the filter material according to the invention. Figure 1a) shows the formation of a first fibre layer from natural fibres 1 and the formation of a second fibre layer from synthetic, biodegradable, heat-sealable fibres 2. The second layer is thus formed using the fibres 2 by deposition on top of the first layer, which is formed by the natural fibres 1. For the purposes of differentiation in the drawing, the natural fibres 1 are shown with horizontal hatching, while the synthetic fibres 2 are shown with approximately vertical hatching.

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Figure 1b) shows how, by means of the stated dewatering of the two layers, in particular the second layer containing the fibres 2, partial interpenetration of the two layers is achieved, the synthetic fibres 2 passing between the natural fibres 1.

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In a further production stage, the partially interpenetrating layers 1 and 2 are dried, during which operation they are heated in such a manner that the synthetic fibres 2 melt and, after resolidification, lie around the fibres 1 in such a manner that these latter fibres are at least partially enclosed. The filter material has thus become heat-sealable (figure 1c).

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Figure 2 shows the essential structure of a papermaking machine, as may be used for the production of a filter material according to the invention. First of all, a suspension

"A" is prepared from the ground natural fibres and water, while a suspension "B" is also prepared from the partially ground synthetic fibres and water.

5 These two suspensions A and B are transferred from their individual tanks (3 and 4) into the papermaking machine via the so-called head box. This essentially comprises a circulating wire (5), which is conveyed through a number of dewatering chambers (6, 7 and 8).

10 By means of suitable pipework and pumping apparatus, which are not shown in any further detail, suspension A, on the wire 5, is passed through the first two dewatering chambers 6, wherein the water is drawn off by the chambers 6 and the dewatering line. This results in the formation of a first fibre layer of natural fibres 1 on the moving wire 5. As the wire 5 moves onwards through the dewatering chambers 7, the second suspension B is introduced, wherein the second layer of synthetic fibres is deposited on the first layer in the dewatering chambers 7. Dewatering proceeds by means of the dewatering line. As the wire 5 bearing the two superposed fibre layers moves onwards through the dewatering chambers 8, further dewatering is performed, as a result of which the two layers partially interpenetrate. The degree of interpenetration may be increased or reduced by appropriate adjustment of the dewatering.

20 The material 9, which has now been formed from natural fibres and synthetic fibres, is removed from the wire and dried. Drying may proceed in various manners, for example by contact drying or by through-flow drying.

25 The units 10 give only a general diagrammatic indication of suitable drying units.

Figure 2 shows three drying cylinders 10, by means of which the formed paper web is dried by the contact process. It is, however, also practicable to pass the formed paper web over only one cylinder and to dry it with hot air without the web lying on this cylinder.

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Heating of the two-layer fibre material causes the synthetic fibres 2 in the mixed layer 9 to melt. After resolidification on leaving the drying apparatus, the synthetic fibres at least partially enclose the natural fibres and the heat-sealable filter material is wound onto a reel 11.

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A second production process for a biodegradable, heat-sealable filter material is performed as follows:

10 If the biodegradable polymer is in pellet form, it may be shaped into fibres using the melt-blowing process and deposited while still hot and tacky onto a substrate, for example a paper made from natural fibres.

This is a prior art process, but the essentials of the process shown in figure 3 are nonetheless briefly described below:

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The dried pellets 12 are conveyed into an extruder 13, in which they are melted and heated to the temperature required for fibre formation. This heated polymer melt then passes into the MB spinneret 14. This spinneret has a large number of small orifices through which the polymer melt is pressed and drawn into fibres. A strong stream of
20 air is directed onto these fibres 15 immediately below the spinneret, the fibres are stretched further, torn into varying lengths and deposited onto a substrate, for example a paper 16, which lies upon a suction roll 17. Since these fibres are still in a hot, tacky state, they adhere to the natural fibres of the paper. Once cool, the material is wound on the winder 18. Typical diameters of these melt-blown fibres are between 2 and
25 7 μm . Figure 3 is a diagrammatic representation of the melt-blowing process.